

# Analysis on Total Factor Productivity of Chinese Information Service Industry and Influencing Factors

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The paper uses the productivity index based on data envelopment analysis (DEA) to calculate the total factor productivity (TFP) from 2008 to 2014, and also compares the differences of TFP changes in three regions: eastern, central and western part. . Then we use the panel data model to seek and discuss the factors affecting the regional difference of total factor productivity growth. Results indicate that Chinese information service industry's total factor productivity shows a rising trend; the investment on education level and information level has a significant role in promoting the improvement of technological progress, technology efficiency and productivity; in addition, R&D, government behavior and urbanization are the important factors that affect regional difference of the development of Chinese information service industry.

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**1.Introduction**

With the increasing maturity of the Internet industry, information service industry becomes the new growth point and strong engine of China's economic development, and boosts production and consumption. So it is particularly important to study the endogenous growth of its economy. In New-Classical Theory of Economic Growth, the total factor productivity(TFP) is the core to measure the economic endogenous growth; its changes can reflect the industry development level and trend clearly.

Abramovitz studied the America economy in 1869~1878, founded that there were other contributing factors of output growth besides the inputs growth of total factor productivity [1]. American scientists Cobb C.W.C and P.H.D Douglas(1928) put forward the famous Cobb-Douglas production function[2]. Recently, R.Solow asserted that total factor productivity growth was the main source of American economic growth in a constant scale reward, and Hicks neutral and profit maximization conditions[3]. In 1984, R.D Banker, A. Charnes and W.W.Cooper created BC<sup>2</sup> model. C<sup>2</sup>R and B<sup>2</sup>C model were used to study the productivity technical effectiveness[4]. Fare(1985)[5] developed the measurement method of total factor productivity change, and also successfully took the experience analysis. In 1994, Fare etc. came up with non-parametric Malmquist index of the total factor productivity growth rate based on DEA[6]. In recent years the relative researches about TFP have appeared in China. Ping Hua(2005)[7] measured the total factor productivity of the variance in 29 Chinese provinces between 1993 and 2001, and the result demonstrates that a high level of education has a positive effect on improving efficiency, technical progress and productivity growth. Xiguo Yin(2008) [8] used the nonparametric productivity index based on provincial panel data to measure the total factor productivity of China. The research showed that international trade and direct foreign investment combining with human capital has an outstanding promotion to the China productivity growth, especially on promoting technology progress as well as the technical efficiency improvement.

In this paper, the data development analysis method is used to measure the TFP of China's information service industry and the situation of the eastern, central and western regions are discussed respectively. Then, we analyzed the main factors influencing the information service industry in China by panel data regress. Finally, according to different factors, the impact of industry is to determine the direction of industrial development.

**2.Methods and the Data**

**2.1 Calculation of Explanatory Variables**

The article introduces the Malmquist productivity index by the distance function C<sup>2</sup>R of DEA model. According to Shephard (1970), the output function which represents production set S<sup>t</sup> from (t) to (t+1) period is defined as follow:

$$S^t = \{(x, y) | \text{in } t \text{ period}\} \tag{2.1}$$

For input  $x \in R_+^N$ , output  $y \in R_+$  the t production possibility set S<sup>t</sup> is defined as:

$$D_0^t(x^t, y^t) = \inf \left\{ \theta \mid (x^t, y^t / \theta) \in S^{t+1} \right\} = \left( \sup \left\{ z \mid (x^t, zy^t) \in S^t \right\} \right)^{-1} \tag{2.2}$$

Based on the existing research, by weighing the pros and cons of TFP productivity

measurement, this paper tries to use the non-parameter productivity index method in the production function to measure and analyze the total factor productivity growth of China's information service from 2008 to 2014, and compare the difference of regional development.

In this article, we mainly studied from the perspective of investment research on the total factor productivity changes in Chinese information service industry, the reference technology is defined as follows:

$$L^t(y^t | C, S) = \{(x_1^t, \dots, x_N^t) : y_{k,m}^t \leq \sum_{k=1}^K z_k^t y_{k,m}^t, m = 1, \dots, M; \sum_{k=1}^K z_k^t x_{k,n}^t \leq x_{k,n}^t, n = 1, \dots, N; z_k^t \geq 0, k = 1, \dots, K\} \quad (2.3)$$

Among them,  $z$  means the weight of each cross section observation values. According to the research of Fare, etc. (1994), two geometric average of productivity index can be used to calculate productivity change, and its equivalent form is as follows:

$$M_0(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{d_0^t(x^{t+1}, y^{t+1})}{d_0^t(x^t, y^t)} \times \sqrt{\frac{d_0^t(x^{t+1}, y^{t+1})}{d_0^{t+1}(x^{t+1}, y^{t+1})} \times \frac{d_0^t(x^t, y^t)}{d_0^{t+1}(x^t, y^t)}} \quad (2.4)$$

Because changes of productivity index can be decomposed into technical efficiency change (EC) and the technological progress (TP), and also the technical efficiency change index can be further decomposed into pure technical efficiency (PC) and scale efficiency index (SC), therefore, estimation (5) can also be expressed as follows:

$$M_i(x^{t+1}, y^{t+1}, x^t, y^t) = \left\{ \left[ \frac{D_i^t(x^t, y^t)}{D_i^{t+1}(x^{t+1}, y^{t+1})} \right] \left[ \frac{D_i^{t+1}(x^{t+1}, y^{t+1})}{D_i^t(x^t, y^t)} \right] \right\}^{1/2} = \frac{D_i^t(x^t, y^t)}{D_i^{t+1}(x^{t+1}, y^{t+1})} \left[ \frac{D_i^{t+1}(x^{t+1}, y^{t+1})}{D_i^t(x^t, y^t)} \times \frac{D_i^{t+1}(x^t, y^t)}{D_i^t(x^t, y^t)} \right]^{1/2} = EC \times TP = PC \times SC \times TP \quad (2.5)$$

## 2.2 Model Setting and Explained Variable

American economist Denison has carried on the classification and quantitative analysis on the influencing factors of total factor productivity growth, which were subdivided into scale economy, the improvement of resource allocation and knowledge progress three factors. Ultimately, his research provided a good analytical framework for the study of total factor productivity. Compared with the analysis of other researchers, this article will divide the main factors of TFP growth affecting China's regional information service industry into the informatization level, education level, R&D investment, the government behavior and the level of urbanization, etc., and put forward the following hypothesis.

### 2.2.1 Model Setting

In the process, we analyze the differences between the contributing factors by using static panel data model. According to the time and cross section features of panel data, the model form must be tested to get effective parameter estimation before estimating. So we use the Hausman test to ensure the validity of the estimation. By the Hausman test, we use fixed intercept model and optimize model by adding index gradually, after that, the growth of total factor productivity under the scope of the research is regarded as explained variable, and the model is set as follows:

$$\ln TFP_{it} = \beta_0 + \beta_1 \times \ln IDI_{i,t-1} + \beta_2 \times \ln EDU_{i,t-1} + \beta_3 \times \ln RD_{i,t-1} + \beta_4 \times \ln GOV_{i,t-1} + \beta_5 \times \ln URB_{i,t-1} \quad (2.6)$$

$TFP_{it}$ , as the dependent variable, is the growth rate of total factor productivity in

information services. As the independent variables, information development (IDI), education development level (EDU), research and development investment (R&D), the government behavior (Govern), and urbanization (Urban) all respectively affect the interpretation of the TFP change.

### 2.2.2 Explained Variables Description

(1) Information Development (IDI)

$$IDI_{i,t-1} = inf_{i,t-1} / gdp_{i,t-1} \quad (2.7)$$

$inf_{i,t-1}$  means i region's Information Service Industry output value in t-1 year;  $gdp_{i,t-1}$  means i Region's GDP output value in t-1 year. Education Development Level (EDU)

$$EDU_{i,t-1} = \sum_{i=1}^n p_{i,t-1} y_{i,t-1} \quad (2.8)$$

$p_{i,t-1}$  refers to a certain level of education corresponding to the proportion of the population,  $y_{i,t-1}$  refers to the education level corresponding to the number of years of education. The specific practices can refer to Qingwang Guo(2005)[9].

(2) Research and Development Investment (RD)

$$RD_{i,t-1} = rd_{i,t-1} / gdp_{i,t-1} \quad (2.9)$$

$rd_{i,t-1}$  means i Region's research and development investment in t-1 year;  $gdp_{i,t-1}$  means the same as above.

(3) government behavior (GOV)

$$GOV_{i,t-1} = govern_{i,t-1} / gdp_{i,t-1} \quad (2.10)$$

$govern_{i,t-1}$  means i Region's government investment in t-1 year;  $gdp_{i,t-1}$  means the same as above.

(4) Urbanization (URB)

$$URB_{i,t-1} = urban_{i,t-1} / people_{i,t-1} \quad (2.11)$$

$urban_{i,t-1}$  means i region's city population in t-1 year;  $people_{i,t-1}$  means i region's population in t-1 year.

## 3. Results

### 3.1 The Measurement Results of TFP in Chinese Information Service Industry

Based on obtained data, the total factor productivity and its decomposition value changes of Chinese information industry are calculated by using the nonparametric method of data envelopment analysis (DEA). Table 1 and Table 2 list total factor productivity change and decomposition respectively during the samples periods of Chinese information service industry.

#### 3.1.1 Annual total Factor Productivity Change Analysis of Chinese Information Industry

According to Tab.1, there are four periods realizing the TFP growth from longitudinal analysis. They are 2008-2010, 2010-2012, 2012-2013 and 2013-2014. 2008-2010 and 2010-2012, particularly, have the largest annual growth increase with 6.3% and 4.7% respectively. Although total factor productivity change of the Chinese information service fluctuates during the period of 2008-2014, it is still moving forward at a speed of 1.1% with the main source of

growth for the technical progress. The technical efficiency change may have certain negative influence on the growth of total factor. Positive role of technological progress is higher than the negativity of technical efficiency improvement, and the total production index appears a state of growth. In the later period, scale efficiency remains immobile while the technology change has a growth rate of 7.3%. Besides, the pure technical efficiency index fluctuates gently around 1, but overall average fall by 3.5%; Scale efficiency index has retained at around 1 every year, and has increased by an average 0.3%; Under the joint action of the pure technical efficiency and scale efficiency, technical efficiency change index fall by an average 5.8%.

Year	EC	TC	PC	SC	Mo
2008-2009	0.962	1.054	0.982	0.98	1.013
2009-2010	0.988	1.077	1.038	0.951	1.063
2010-2011	0.779	1.297	0.856	0.91	1.011
2011-2012	0.982	1.003	0.975	1.007	0.985
2012-2013	1.023	1.024	0.938	1.091	1.047
2013-2014	0.939	1.012	1.011	0.929	0.951
Average	0.942	1.073	0.965	0.976	1.011

**Table 1:** Average Productivity Index and Its Decomposition of the Chinese Information Service Industry

### 3.1.2 TFP Change Difference Analysis in the Development of Chinese Information Service Industry Region

Province	EC	TC	PC	SC	Mo
China	0.942	1.073	0.965	0.976	1.011
Tianjin	0.967	1.094	0.951	1.016	1.058
Hebei	1.018	1.062	1.000	1.018	1.080
Shanxi	1.151	0.994	1.115	1.032	1.145
Liaoning	0.914	1.078	0.919	0.995	0.985
Jilin	0.999	1.026	1.006	0.993	1.026
Guangdong	0.983	1.083	1.000	0.983	1.065
Shanghai	1.001	1.013	0.986	1.015	1.013
Jiangsu	0.978	1.091	0.992	0.986	1.067
Zhejiang	0.907	1.078	0.901	1.007	0.978
Anhui	0.901	1.083	0.929	0.969	0.975
Fujian	0.924	1.098	0.931	0.993	1.014
Jiangxi	0.945	1.101	0.966	0.979	1.041
Shandong	0.899	1.032	0.901	0.998	0.928
Henan	0.938	1.005	0.941	0.997	0.943
Inner Mongolia	0.904	1.127	0.936	0.965	1.019
Beijing	0.977	1.045	1.000	0.977	1.021
Hebei	0.926	1.080	0.952	0.973	1.000
Hunan	0.887	1.098	0.936	0.948	0.974
Hainan	0.889	1.098	0.933	0.953	0.976
Guangxi	0.887	1.071	0.895	0.991	0.950
Chongqing	0.936	1.087	0.954	0.981	1.017
Sichuan	0.978	1.059	0.986	0.992	1.036
Guizhou	0.929	1.096	1.031	0.901	1.018
Yunnan	0.911	1.098	0.958	0.951	1.000
Tibet	0.910	1.098	1.017	0.895	0.999
Shaanxi	0.889	1.073	0.894	0.995	0.954
Gansu	0.911	1.112	0.951	0.958	1.013
Qinghai	0.983	1.048	1.000	0.983	1.030
Ningxia	0.911	1.079	0.995	0.916	0.983
Xinjiang	0.911	1.098	0.968	0.942	1.000
Heilongjiang	0.979	1.083	0.996	0.983	1.060

**Table 2:** Average Productivity Index and Its Decomposition of Provincial Information Service Industry (2008-2014)

We found that there was a big variety of total factor productivity changes among the Chinese provincial information service according to Table 2 from horizontal comparison. Similar to the changes in front of the national, the variety of technological progress is still the kernel changes in total factor productivity differences between provinces information services. To research more in-depth on regional characteristic and difference of total factor productivity in information service, we will divide 31 provinces into three big economic regions: eastern, central and western according to their economic development characteristics by using Eviews 6.0. Table 3 shows the three major economic regions to total factor productivity changes in information services; we will have a detailed analysis.

Region	EC	TC	PC	SC	Mo
China	0.942	1.073	0.965	0.976	1.011
Eastern	0.945	1.072	0.951	0.993	1.012
Central	0.959	1.066	0.975	0.982	1.020
Western	0.926	1.085	0.978	0.948	1.004

**Table 3:** Average Productivity Index and Its Decomposition of Regions Information Service Industry (2008-2014)

Table 3 shows the TFP changes in information services of China in three areas. In the whole, the TFP change of the central area is better than the national average and is the highest of 3 regions (Eastern: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi, Hainan, Chongqing; Central: Inner Mongolia, Jilin, Amur River, Anhui, Jiangxi, Henan, Hebei, Hunan; Western: Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Sinkiang). However, the change index is small in eastern and western, and this may be due to the hard spread of technology by themselves. Meanwhile, the change trend of regions are coincident with national except eastern area, which fully shows that, central and western regions have achieved big promotions in technology innovation with the support of relevant national policies. And the technological progress is the main cause of information service industry TFP growth. Totally, the TFP change of Chinese information industry presents an upward trend, but its speed has fallen.

### 3.2 Analysis of the Influence Factors about the Development of Chinese Information Service Industry Based on the Panel Data

We can find significant differences among three regions by measuring Chinese provinces and regional information service productivity changes from 2008 to 2014. According to the above factors influencing TFP growth evaluation model, the results of the analysis are as follows:

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)
C	-14.251	-14.265	-13.634	-9.84	-14.769
lnIDI	0.074	0.074	0.105	0.223	0.139
lnRD		-0.001	-0.001	0.009	-0.028
lnEDU			0.013	0.049	0.033
lnGOV				0.103	0.053
lnURB					-0.157
Adj R <sup>2</sup>	0.9997	0.9997	0.9997	0.9998	0.9998
F	706431	683524	662416	695938	714075
D.W.	1.3753	1.375	1.3684	1.4929	1.5152

**Table 4:** Regression Results of the Influence Factors about Regional Information Services in

## TFP

By Model (1), the coefficients in front of the variable information level are positive. With the increase of all the factors, it is bigger and bigger, which shows that the improvement of informatization level has a positive promoting role in information service industry total factor productivity growth. Informatization has not only provided technical support for the development of information services, but also greatly improved production efficiency of each section.

By Model (2), the coefficient of variable R&D is small and negative. This shows that technology advantage hasn't been fully reflected in recent years, therefore the ability to turn scientific research into technology innovation should be enhanced.

By Model (3), we conclude that the improvement of education level promotes TFP growth in information services, therefore, we should invest in education to implement the knowledge diffusion, and strengthen regional elements flow to improve the level of informatization.

By Model (4), the coefficient is relatively small but positive before the government behavior and it shows that the current Chinese government scale and interventions for information service industry have little effect on total factor productivity. Theoretically, urbanization brings spatial agglomeration to population and economic activities, which can directly promote the trade efficiency and the evolution of the division of labor, thus improving and pulling the TFP growth.

By the Model (5), however, the coefficient before the urbanization level is negative. It may be because the current information service industry level is still low in China, and strong agglomeration and scale economies have not formed yet.

## 4. Conclusion

Based on the information panel data of China's 31 provinces from 2008 to 2014, this paper uses the productivity index (TFP) to analyze the dynamic change of information service industry, and illustrates the various factors affecting TFP, and then draws the conclusions: China information service TFP shows a growing trend, and technological progress is the largest driving power to achieve the overall growth. Meanwhile, the three areas (eastern, central and western) have different regional economic development in Chinese terms of information service, especially the central region of TFP. When it comes to the contributing factors, high level of informatization and education have a great positive effect on informatization development and the government behavior can effectively promote growth in information services TFP at present while the R&D investment and urbanization level have certain negative influence on development.

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